Perhaps in no one instance of reported resistance to disease and insect attack has the nature of the immunity been fully ascertained or circumscribed, although it is generally conceded as being highly desirable to determine the particular immunizing properties. In some cases it is thought to be due to hardiness of the individual, or vigor of growth; in others, to the durability, composition, or peculiarity of structure of the affected tissue.

In the plantlet stage of growth there is not much difference between the corn and the teosinte except that the leaves and stem of the latter are narrower and more slender. As the plants grow older the leaves of the teosinte are tougher and more leathery in texture, with pronounced teeth along the edges of the leaf. The corn leaves become slashed and torn to ribbons by wind storms, while the long narrow, and tough leaves of the teosinte remain entire. The sap of the corn plant is sweeter than the sap of the teosinte.

In the above-mentioned features the F_1 resembles the teosinte more than it does the corn. Since the aphis are sap suckers, the sweeter juice and more readily penetrated epidermis of the corn plant may be the deciding factors of immunity for the teosinte and the hybrid. This remarkable immunity apparently provided material upon insect parasitism as a means of determining genetic relationship and elucidation of the problem of inheritance of immunizing properties in plants.

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SPECIAL ARTICLES

THE TILLERING OF WHEAT

DURING the past eight years the writer has made a rather extended study of the tillering of winter wheat. The factors studied may be divided into two general classes, viz., heredity and environment. It has been found that the tendency to tiller appears to be largely a varietal characteristic. In order to study the behavior of the wheat plant with respect to tillering it was found necessary to plant the kernels in hills 6 by 6 in. apart. Two kernels were planted and later the plants thinned to one per hill. This method of seeding allowed the plant sufficient space to express rather fully its tendency to tiller. Seedings were also made by drilling in rows as is usually done in practical wheat culture. In this case, however, the number of tillers per plant could not be so accurately determined at harvest owing to the crowded condition of the plants in the row. As the plants came up the number was determined for a definite length of drill row. At harvest the total number of culms within this space was noted and divided by the number of plants. This gave the average number of tillers per plant. Where the wheat was seeded in hills each plant was cut separately and the culms counted. The mean for each variety was then determined by dividing the total number of culms by the number of plants. More than 150 varieties and strains of winter wheat were included in these tests. It was noted that the bearded wheats as a class seem to tiller more freely than the smooth. In order to test this characteristic of varieties more thoroughly identical varieties were grown the same season on both fertilized and untreated soil. All of the experiments were conducted in the field. The following table gives the average number of tillers per plant for four varieties of wheat, two smooth and two bearded.

TABLE I

Number of Tillers per Plant of Four Varieties Grown under Different Conditions

Test No.	Smooth		Bearded	
	Red Wave	Invincible	Red Wonder	Mediterranean
1	5.13	4.74	6.19	7.95
2	5.05	4.13	6.73	6.72
3	5.45	6.24	8.81	8.90
4	3.39	4.04	5.58	6.68
5	7.10	6.28	8.58	9.39
6	2.94	2.78	4.02	4.44
7	4.08	4.81	6.33	7.16
8	2.20	2.73	3.15	4.63
9	1.09	1.22	1.77	1.92
10	1.02	.98	1.29	1.45
11	.98	.97	1.06	1.20
12	1.14	2.04	2.95	2.63
13	1.01	1.07	1.81	1.69
14	1.01	1.19	1.46	1.39

As indicated in the table these varieties were grown under 14 different conditions, covering a period of eight years. In tests one to eight inclusive the varieties were grown individually by the hill method, while in the remainder of the tests the grain was grown in drill row. It will be noted from Table I. that the bearded varieties have produced more tillers per plant in every case.

In Table II. is given the summary of the results with all varieties included in the different tests on tillering. The number of varieties together with their repetition in the 13 different tests amounts to 973 cases. For the sake of convenience the ten highest and the ten lowest tillering varieties in each test are separated into a smooth and a bearded group.

TABLE II

Summary of Variety Test on Tillering showing the Proportion of Bearded and Smooth Varieties in the Highest and the Ten in Each Test

Test No.	No. of Varieties			Highest Ten		Lowest Ten		No. of Tillers per Plant	
	Total	Bearded	Smooth	Bearded	Smooth	Bearded	Smooth	Bearded	Smooth
1	84	51	33	10	0	1	9	1.37	1.12
2	76	37	39	9	1	2	8	2.15	1.95
3	57	25	32	8	2	0	10	1.26	1.11
3–*a*	57	25	32	7	3	1	9	1.08	1.01
4	67	31	36	9	1	2	8	7.70	6.02
5	58	29	29	9	1	3	7	3.21	2.85
5–*a*	58	29	29	8	2	3	7	1.68	1.46
5–*b*	58	29	29	9	1	4	6	1.10	1.06
6	113	60	53	10	0	2	8	1.40	1.23
6–*a*	113	60	53	9	1	2	8	1.18	1.04
7	53	25	28	7	3	1	9	1.28	1.13
8	80	42	38	7	3	1	9	2.95	2.50
8–*a*	80	42	38	9	1	2	8	1.63	1.35
Total..........				111	19	24	106		
Per Cent........				85	15	20	80		

The number of tillers per plant refers to the average for all bearded and all smooth included in each test. It will be seen that the larger proportion of the high tillering varieties in every test is bearded while the greater number of the low tillering varieties is smooth. Of the 130 cases of the ten highest tillering varieties, 111, or 85 per cent., are bearded; of the 130 cases of the ten lowest tillering varieties, 106, or 80 per cent., are smooth. The results of these tests indicate that the bearded varieties have a greater capacity for tillering than the smooth.

In the study of environmental factors it was found that the rate of seeding a space per plant has a marked influence on the number of tillers produced per plant. Close seeding resulted in a smaller number of tillers per plant, earlier maturity and a better quality of kernel than wide seeding. The time of seeding determines to a large extent the rate of tillering. Early seeding is accompanied by a larger number of tillers per plant than late seeding. The time of seeding, the number of tillers per plant, the yield per plant and the quality of grain are closely correlated. The competition between plants induced by heavy seeding is more marked among smooth wheats than among the bearded. It appears that heavy seeding has a greater effect in lessening the number of tillers, the length of culm, spike, and yield of grain in smooth wheats than in bearded. The fertility of the soil is a factor that directly affects the rate of tillering. Nitrogen and phosphoric acid seem to stimulate the production of tillers; potash has little or no effect. The relation of tillering to yield is shown by the increase in the yield per spike as the number of tillers per plant increases to 4 or 5, beyond this the yield per spike is more or less uniform. The low tillering plants of a variety produce a smaller yield per spike, and the grain is of poorer quality. These experiments have shown quantitatively the effects on the rate of tillering of such factors as time and rate of seeding, the kinds of fertilizer and the relation of the number of tillers per plant to other characters. The tendency of bearded wheats to tiller more freely than the smooth has not been brought before to the attention of the wheat grower. A close analysis of these results indicates that there is a physiological difference between the two types of wheat which may mean that the bearded sorts are able to make better use of the plant food supplied or are able to extract it from

the soil more easily than the smooth type of grain.

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A MEANS OF TRANSMITTING THE FOWL NEMATODE, HETERAKIS PAPILLOSA BLOCH[1]

A recent experiment demonstrated that the fowl nematode, *Heterakis papillosa* Bloch[2] may be transmitted to chickens by the feeding of a dung earthworm, *Helodrilus gieseleri hempeli* Smith.[3] The thirteen fowls (three of them controls) used in the experiment were hatched in an incubator, reared in a worm-proof field cage,[4] and given food free from animal tissues, while the dung earthworms were taken from a poultry yard in which the fowls were heavily infected with *H. papillosa.* When these chicks were about five weeks old, they were given dung earthworms every few days until each chick had ingested approximately forty worms. Of ten chicks so fed, four became infected with *H. papillosa,* the results of these examinations being as follows:

Chick 104, examined sixty-four days after first feeding, nine nematodes in the cæca.

Chick 117, examined one hundred thirty-seven days after first feeding, one nematode in the right cæcum.

Chick 128A, examined twenty-nine days after feeding, two nematodes in the cæca.

Chick 130A, examined twenty-seven days after feeding, two nematodes in the cæca. The six remaining chicks and the three controls were free from nematodes.

As is well known, these small nematodes commonly occur in the cæca of fowls, although they are not infrequently found in the large intestine. Of three hundred ninety-five chickens taken locally and examined in this laboratory during the last three years, two hundred ninety-three (74.1 per cent.) were infected with *H. papillosa.* The average infection was 34.4 nematodes, but a single infection of one hundred nematodes is not uncommon, and in one instance a fowl contained three hundred twenty-six of these parasites.

The means by which chickens become infected with *H. papillosa* is not wholly understood. Evidently, in some cases, a dung earthworm transmits these nematodes, but whether the relation between the two worms is one of parasitism or merely that of an association has not been fully determined. The presence of certain nematodes both free in the nephridia and imbedded in the muscles of earthworms furnishes a suggestive hypothesis. Dung earthworms are of common occurrence in the local poultry yards, and it might be possible to account for the rather heavy nematode infection of fowls from this source alone. But Leuckart long ago pointed out that *H. papillosa* may develop directly, according to Railliet and Lucet,[5] who, by feeding to a fowl eggs removed from the uterus of *H. papillosa,* secured a direct infection of fifteen of these nematodes. The writer, likewise, has obtained direct infections by giving eggs of this nematode to fowls reared under controlled conditions. These data indicate that the relation of the nematode to the earthworm is that of an association, in which case the eggs of the former might be carried on the slimy surface of the earthworm or in its engulfed food. However, the evidence is not such as to preclude the possibility that this earthworm, *H. gieseleri hempeli,* may, in some way, serve as an intermediate host of *H. papillosa,* and it is hoped that experiments now under way will reveal the nature of this relation.

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[1] Contribution No. 19 from the Zoological Laboratory, Kansas State Agricultural College. Aid of Adams Fund.

[2] The identification of this nematode has been verified by Dr. B. H. Ransom, Zoologist, B. A. I., U. S. Dept. Agr., Washington, D. C.

[3] The earthworms were identified by Professor Frank Smith, University of Illinois.

[4] The field cage with its floor and eighteen-inch walls of cement is so constructed as to be practically insect-proof also. Examinations of control chickens every few weeks for three years have not yielded a single parasitic worm.

[5] Railliet, A., et Lucet, A., "Observations et expériences sur quelques helminths du genre *Heterakis* Dujardin," *Bull. Soc. Zool. France,* Par., 17: 117–120, 1892.